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REPORT ON WATER POLLUTION CONTROL. LITTLE COLORADO RIVER DRAINAGE BASIN. ARIZONA-NEW MEXICO

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Report on
Water Pollution Control

LITTLE COLORADO RIVER DRAINAGE BASIN

(ARIZONA—NEW MEXICO)

1953

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Water Pollution Series 43

Report on Water Pollution Control

LITTLE COLORADO RIVER BASIN
Colorado River Drainage Basin

Prepared by:

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Division of Water Pollution Control
Pacific Southwest Drainage Basins Office

in cooperation with

ARIZONA
State Department of Health

NEW MEXICO
State Department of Public Health

April 1953

TABLE OF CONTENTS

	Page No.
Introduction	(a)
Acknowledgments	1
Summary	3
Conclusions	6
Recommendations	8
General Description -	
Historical Background	11
Physical Description	13
Economic Development	17
Uses of Water Resources	21
Pollution Contributed to Water Resources	27
Damages to Water Resources from Pollution	34
Benefits Resulting from Pollution Prevention and Abatement	36
Pollution Prevention Measures in Effect	38
Pollution Prevention Measures Required	43
MAPS	
Map #1 - Existing Primary Water Uses	19
Map #2 - Sources of Municipal Pollution and Existing Treatment Facilities	25
Map #3 - Sources of Industrial Pollution and Existing Treatment Facilities	31
Map #4 - Municipal Waste Treatment Needs	41
Map #5 - Industrial Pollution Abatement Needs	49

TABLES

	Page No.
Table I - Hydrology Data - Little Colorado River	16
Table II - Analyses of Little Colorado Basin Wastes	28
Table A - Sources of Pollution - Municipal	33
Table B - Sources of Pollution - Industrial	33
Table C - Existing Treatment Facilities - Municipal	39
Table D - Existing Treatment Facilities - Industrial	40
Table E - Adequacy of Existing Treatment Facilities - Municipal	40
Table F - Adequacy of Existing Treatment Facilities - Industrial	40
Table G - Progress in Construction of Pollution Abatement Facilities	40
Table H - Wastes Treatment Needs - Municipal	44
Table I - Industrial Wastes Pollution Abatement Needs	44
Table J - Status of Municipal Action on Pollution Abatement Needs	45
Table K - Status of Industrial Action on Pollution Abatement Needs	45
Table L - Municipalities and Industries Needing Improvements for Abatement of Pollution	46

APPENDIX

Appendix I	
Table 1 - Basic Data on Sources of Municipal Pollution	51
Table 2 - Basic Data on Sources of Industrial Pollution	55
Appendix II - Pollution and Abatement Measures Required at Certain Unsewered Communities of Arizona	56

INTRODUCTION

The Federal Water Pollution Control Act, Public Law 845, passed by the 80th Congress in June 1948, requires the Surgeon General of the Public Health Service to cooperate with other Federal agencies, with state and interstate water pollution control agencies and with municipalities and industries in the preparation or adoption of comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof, and improving the sanitary condition of surface and underground waters.

In developing these programs, due regard must be given to improvements necessary to conserve the Nation's waters for public water supplies, propagation of fish and aquatic life, recreational purposes, agricultural and other legitimate uses.

Recognizing the fact that full technical information was not available to permit the development of such comprehensive programs immediately for most of the Nation's waters, the Public Health Service envisioned the development of a series of reports to cover the interim period prior to the development of comprehensive water pollution control programs. The first of these reports were the Summary Reports which were prepared for the fifteen major drainage basins of the country on the basis of information readily available as of July 1, 1950. The second group of reports of this series, of which this is one, are reports on several sub-basins of the country's major drainage basin areas. Since development of comprehensive water pollution control programs is to proceed as rapidly as conditions permit, only a limited number of these interim sub-basin reports are to be completed, and the majority of these will be for interstate sub-basin areas. These reports are based on available data and will provide a reference point for measuring progress; provide a guide to needed additional data; provide a basis for the logical development of comprehensive programs; provide a basis for approval of loans to states, interstate agencies and municipalities at such time as the Congress makes available funds for this purpose; and serve to inform the public on the water pollution control problem and needs for the sub-basin concerned.

This report is based upon data available as of January 15, 1953, and has been compiled through and in cooperation with the state water pollution control agencies, but should not be considered a detailed engineering investigation of the Little Colorado Sub-Basin. Through these cooperating agencies additional data have been obtained from other state officials, county and city officials, and representatives of industry. Federal agencies also have been of great assistance.

The sub-basin reports present information about the ways the water resources of the area are used, the pollution entering these water

resources and the resulting damages, the benefits which may result from pollution prevention and abatement, pollution prevention measures not in effect, and those which appear to be needed.

Since the sub-basin reports are based on data which are presently available, they do not discuss the present and future best uses of the waters of the sub-basin as such uses may be related to pollution control. Such considerations will be included as a part of the comprehensive water pollution control programs which will be developed later.

The deficiencies in data and the gaps in information indicated in these sub-basin reports are as significant as the presentation of available facts and statistics. They indicate the work that still needs to be accomplished by water pollution control authorities for the preparation of comprehensive programs.

Data and knowledge now available are sufficient, however, to permit the immediate solution of many of the pollution problems within the Little Colorado Sub-Basin without awaiting the results of additional surveys and studies.

A sincere effort has been made by all who contributed to this report to present a fair picture of the complex water pollution problems in the Little Colorado Sub-Basin and to present reasonable conclusions and recommendations. It is our hope that this report, as a step in the cooperative development of an ultimate comprehensive water pollution control program, will help in safeguarding the water resources of the Little Colorado Sub-Basin.

ACKNOWLEDGMENTS

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Arizona State Department of Health
New Mexico Department of Public Health
Arizona Game and Fish Commission
New Mexico Department of Game and Fish

The various Federal agencies from which assistance and data were received include:

Department of the Army
Corps of Engineers

Department of the Interior
Fish and Wildlife Service
Geological Survey
Bureau of Reclamation
National Park Service
Office of Indian Affairs

Department of Agriculture
Soil Conservation Service
Forest Service

Department of Commerce
Weather Bureau

Valuable data also were obtained from the Research Division of the Valley National Bank, Phoenix, Arizona, and from the Bureau of Business Research, University of New Mexico, Albuquerque, New Mexico.

SUMMARY

The Little Colorado River basin includes an area of approximately 27,800 square miles lying immediately west of the Continental Divide in northwestern New Mexico and northeastern Arizona. About four-fifths of this basin are within the borders of Arizona. Federal lands occupy a substantial portion of the basin--about one-fourth of the area being Indian Reservations. Two tributaries, both intermittent over their entire length, are interstate streams although the main stem of the Little Colorado lies entirely within the State of Arizona.

In spite of the large area of land drained by the Little Colorado and its tributaries, water is in extreme scarcity throughout the entire watershed owing to the low precipitation and the high evaporation characteristic of the arid Southwest. The Little Colorado River flows perennially over only 50 miles of its 315-mile length. This river yields the lowest run-off per unit area of watershed of any major river of the United States.

The principal industries of the Little Colorado basin are farming, stockraising, lumbering, and tourist services. The extreme scarcity of water definitely limits the area of land that can be profitably cultivated; consequently most of the basin lands are used for grazing. Water scarcity is emphasized by the fact that with all suitable firm water supplies being fully utilized, less than 0.3 percent of the basin area is under cultivation. Tourists represent the greatest single source of income to the basin. U. S. Highway 66, often called the "Main Street of America" in that it carries more transcontinental motor traffic than any other highway, traverses the basin and large numbers of tourists are attracted to the area each year by the many spectacular scenic wonders and the indigenous Indian cultures.

Municipal use and irrigation constitute the principal water uses of the basin. Municipal use, as indicated by that consumed in the communities for which water use data are available, averages about 88 gallons per day per capita. Most of the communities in the basin utilize deep wells for domestic water needs inasmuch as suitable firm supplies of surface water are available in only a few locations. From the viewpoint of consumers served, however, almost an equal number are served by surface as by underground water. Winslow and Flagstaff, the two largest communities of the Little Colorado basin, are so situated that water from mountain lakes or impoundments can be tapped.

Comparatively little industry has developed in the Little Colorado basin. It consists chiefly of lumbering and milling of lumber products, food processing, and the production of stone and clay products. Irrigation now utilizes all of the suitable firm surface water supplies available which are sufficient to serve less than 50,000 acres of land.

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Very limited quantities of underground water are used for irrigation and these mostly in the headwater areas. Although the underground water resources have not been fully explored, the fact that they have been so little exploited in an area where water is so precious a commodity indicates little promise for much additional irrigation water from the subsurface sources.

Chemical water quality generally is satisfactory for all uses throughout the headwater areas of the basin. The river waters quickly acquire heavy salt burdens as they progress downstream. In the mainstem Little Colorado, the meager information available indicates that the river water often is of questionable quality for irrigation by the time it has reached River Mile 250 and, according to the Bureau of Reclamation, is too saline for irrigation below River Mile 190. The dissolved solids are obtained from the leaching of rock formations high in soluble salts and from mineral springs commonly found in many parts of the basin.

The chemical quality of the underground waters of the basin vary widely in different locations. Analyses show that waters from different wells range from less than 100 to over 6,000 parts per million of total dissolved solids concentration. Generally speaking, the wells yielding the poorest chemical quality water are found in shale-sandstone formations and in the sands and gravel of Cottonwood Wash, Leroux Wash, and the bottom lands along the main stem.

All streams of the Little Colorado River basin carry very large quantities of sediment--particularly during flood flows. The friable soil and sparse vegetal cover, characteristic of the basin, offer a minimum of resistence to erosion which is severe over most of the basin area.

An extremely low population density (about 3 inhabitants per square mile) has confined water pollution problems to the scattered populated centers of the basin. Pollution of local importance exists in several areas of the basin and calls for remedial measures.

At the present time, there are 45 sewered communities and institutions in the Little Colorado basin at which an estimated population of 35,000 is served. Only one sewered community (Flagstaff, Arizona, with a sewered population of 6,770) and one Indian Hospital (At Winslow, Arizona, estimated population served 75) lack some form of domestic waste treatment. Most of the sewage treatment plants (29 of 43) provide primary treatment although the 14 secondary-treatment plants of the basin serve a slightly larger number of people than do the 29 primary-treatment plants. Although the percentage of sewered communities providing waste treatment facilities is very high, the adequacy of plant capacity and the level of operation leave much to be desired. While 43 of the 45 sewered communities and institutions provide waste treatment facilities, 31 of the 43 plants no longer produce a satisfactory

effluent because of overloading or obsolescence. The adequacy of operations is even worse--being questionable at 33 of the 43 plants. Of the 31 sewage treatment plants considered in need of renovation or replacement, 26 are located on Federally-owned land over which the State Health authorities have no direct jurisdiction. In brief, almost two-thirds of the sewered population of the Little Colorado River Basin are served by unsatisfactory sewage treatment plants.

Ineffective protection to public health also arises from the individual waste disposal facilities in the larger unsewered communities of the basin as well as those in unsewered fringe areas that have developed about some of the major cities. Population densities in these unsewered areas have now attained the concentration where the individual unit no longer can be considered as an acceptable answer to the community waste disposal problem.

The cost of specific water pollution control measures needed at the sewered communities within the Little Colorado Basin, exclusive of the Federally-owned lands, is estimated by the State Health authorities at $224,000. Approximately $250,000 will be required to provide acceptable waste treatment facilities at installations under the jurisdiction of the National Park Service and the Bureau of Indian Affairs. In addition, waste collection systems and treatment facilities in the amount of about $640,000 are needed at the communities not currently sewered.

CONCLUSIONS

1. The water resources of the Little Colorado Basin are in extremely short supply and are a very important limiting factor precluding further development of the basin area. Current water demands of the headwater areas consume all firm supplies of surface waters leaving vast reaches of dry stream bed below. As yet, there is little evidence that the underground water resources will support substantial further development. It is, therefore, of utmost importance that all available water resources of the basin be kept fully protected against the inroads of man-made pollution.

2. Because water is in such extreme scarcity, none can be allocated to the dilution of domestic or industrial wastes. An unusually high degree of treatment for all wastes is required in the interests of public health. This situation extends beyond the interests of the local population for the basin is subject to extremely heavy tourist travel.

3. The natural pollutants, salt and sediment, are of great importance throughout the basin area. Dissolved solids leached from natural saline deposits are in sufficient concentrations in many locations as to render the waters, both surface and underground, unfit for either domestic or agricultural usage. The sediment loads of the streams are extremely heavy.

4. The state and Federal agencies concerned with water pollution control in their respective areas of the Little Colorado Basin have made commendable progress in securing domestic waste treatment at all but two of the 45 sewered communities and institutions within the basin area. Encouraging as this situation seems, it is also a fact that only 7 of the 43 domestic waste treatment plants within the basin are producing an effluent acceptable to health authorities. A number of pollution abatement measures currently are recognized as essential. These include two new sewage treatment plants, facilities for additional treatment of wastes at 25 existing plants, and the entire replacement of six existing plants. Operations should be improved at 33 sewage treatment plants. In addition, there are some communities currently unsewered at which both waste collection systems and waste treatment facilities are required as are the extension of municipal sewers into fringe areas that have developed around several of the larger communities of the basin. The cost of providing effective waste treatment throughout the Little Colorado Basin has been estimated by state and Federal health authorities at $1,114,000.

5. The state agencies concerned with water pollution abatement lack sufficient funds and personnel to obtain the basic information required for the preparation of a sound comprehensive program of pollution abatement or to prosecute a water pollution control program commensurate with needs. These agencies likewise lack the resources for a program

of public education that will be required to put a comprehensive pollution control program, once drafted, into effect. Public awareness of the need for, and the benefits to be derived from, water pollution control is generally lacking throughout the Little Colorado River Basin.

6. The State of Arizona does not have comprehensive water pollution control legislation. New Mexico lacks any comprehensive water pollution control law, as such; however, regulations have been adopted by the State Board of Health which provide for the prevention, abatement, and control of pollution of the waters of the state in light of all legitimate uses.

RECOMMENDATIONS

It is recommended that:

1. A comprehensive program of water pollution control be developed for the Little Colorado River Basin as a guide to the most effective use of the extremely limited water resources of the basin and to establish a recognized policy by which adequate water quality will be preserved in the future.

2. Current deficiencies in basic information concerning water pollution and its effects upon municipal, industrial, and agricultural water usage be corrected at the earliest possible date to permit planning a comprehensive program to protect water quality. The current deficiencies of basic data, however, should in no way preclude immediate action upon water pollution abatement measures now known to be needed.

3. Acceptable and feasible standards for the sanitary quality of irrigation water be developed and applied where indicated so that damage to this essential water use of the basin can be assessed and remedial measures installed, where indicated, at the earliest possible date.

4. A single agency be established in each state to administer the water pollution control program and that this agency be representative of all groups having valid interests in water uses and pollution control.

5. All municipal, state, and Federal agencies, as well as industries, organizations, and individuals having valid interests in water uses affected by pollution, be invited to cooperate with the official water pollution control agencies in drafting a comprehensive pollution abatement program and in emphasizing to the general public the recognized needs for, and benefits to be derived from, pollution abatement measures.

6. Sufficient state funds be provided to enable the state water pollution control agencies: (1) to increase their technical staff commensurate with recognized needs; (2) to expedite the development and activation of a comprehensive water pollution control program; (3) to develop a sound educational program in the field of water pollution control for the public; and (4) to promote and assist community planning for effective pollution abatement measures.

7. In accordance with the January 1953 recommendations of the state water pollution control agencies and the U. S. Office of Indian Affairs, the following remedial actions be taken:

A. New waste treatment facilities be provided at:

Flagstaff, Arizona
Santa Fe Railroad Shops, Winslow, Arizona
Snowflake Dairy, Snowflake, Arizona
U. S. Office of Indian Affairs' Hospital, Winslow, Ariz.

B. Existing waste treatment facilities be replaced at:

Moenkopi, Arizona
Oraibi, Arizona
Petrified Forest National Monument (2 installations), Arizona
Springerville, Arizona
Winslow, Arizona

C. Additional waste treatment facilities be provided at:

Cheechilgeetho, New Mexico
Cornfields, Arizona
Fort Defiance, Arizona
Ganado, Arizona
Gallup, New Mexico
Greasewood, Arizona
Iyanbito, New Mexico
Joseph City Dairy, Joseph City, Ariz.
Keams Canyon, Arizona
Kin Li Chee, Arizona
Klogetah, Arizona
Leupp, Arizona
Pinedale, New Mexico
Pinon, Arizona
Polacca, Arizona
Rehoboth Mission, New Mex.
St. Johns, Arizona
Sawmill, Arizona
Seba Daiki, Arizona
Shungopavy, Arizona
Steamboat, Arizona
Tolani Lakes, Arizona
Toreva, Arizona
Tuba City, Arizona
Westover Dairy, Joseph City, Arizona
Wide Ruins, Arizona
Window Rock, Arizona

D. Plant maintenance be improved at:

Crystal, New Mexico
Fort Wingate School, New Mexico
Navajo Wingate Village, New Mexico

E. A sewage collection system and a new sewage treatment plant be provided at the following communities:

Eager, Arizona
Joseph City, Arizona
Lakeside, Arizona
Showlow, Arizona
Snowflake, Arizona
Taylor, Arizona

F. Sewage collection systems be extended, and sewage treatment plants be enlarged where needed, to serve the currently unsewered suburban areas that have developed around the following communities:

Flagstaff, Arizona
Hotevila-Bacobi, Arizona
Moenkopi, Arizona
Oraibi, Arizona
Sawmill, Arizona
Shungopavy, Arizona
Springerville, Arizona
St. Johns, Arizona
Toreva, Arizona

8. A study of the possibilities of water conservation through the reclamation of waste treatment plant effluents be undertaken.

9. Soil conservation and groundwater investigational programs be expanded and accelerated in pertinent areas of the Little Colorado River Basin to the end that economically feasible measures for increasing storm-water percolation to underground storage and decreased water pollution from eroded soil can be effected at the earliest possible date.

HISTORICAL BACKGROUND

Little is known about the earliest inhabitants of the Little Colorado Basin although artifacts and ruins indicate that it was inhabited by cave, cliff, and mudhouse dwellers some 8,000 to 10,000 years ago. Indian legends hold that these people were frightened from the area by volcanic activity in the San Francisco Mountains. More recently, the Anasazi--or "ancient people"--occupied parts of the basin from about the beginning of the Christian era to 1200-1300 A.D. when their civilization crumbled under the impact of severe and prolonged drought. The pueblo-dwelling Hopi and Zuni Indians now living in parts of the Little Colorado Basin presumably are descendents of these people. The Navajo and Apache Indians--characteristically nomads--are believed to have entered the Little Colorado Basin area about 1,000 years ago as wanderers from the plains Indians of the Midwest. Apparently all of the early inhabitants were agriculturists--farming by irrigation with the limited quantities of water available and their civilizations waxing or waning depending upon the abundance of water.

The first white man to enter the Little Colorado Basin was Friar Marcos de Niza who preceded Coronado's expedition of 1540 by one year. The Spanish Conquistadores from Mexico failed to find the wealth they sought in the arid, inhospitable country and soon departed leaving little evidence of the white man's civilization.

White colonization of the basin was begun by Mexicans from the South about 1800 in the vicinity of St. Johns, Arizona. Cattlemen from Texas appeared about 1850. The greatest impetus to white settlement of the basin stemmed from the arrival of Mormon pioneers from the North shortly after the successful crossing of the turbulent Colorado River in 1864. The Mormons founded a missionary settlement at Moenkopi in 1871 about two miles from the present site of Tuba City. Shortly thereafter, companies of Mormon families established colonies from which the present communities of Joseph City, St. Johns, Springerville, Snowflake, Tuba City, and Winslow developed. The Mormon pioneers to the area again demonstrated their characteristic talents at transforming the desert--at least within the limits imposed by available irrigation water--into productive agricultural lands. Further colonization followed construction of the Atlantic and Pacific Railroad (later absorbed by the Atchison, Topeka, and Santa Fe Railroad) down the Rio Puerco and along the Little Colorado in 1882. The four principal cities of the basin--Gallup, Holbrook, Winslow, and Flagstaff--subsequently developed as service points for the railroad.

The Little Colorado River proved too tempestuous a stream for even the competent early-day Mormon irrigationists. Every effort to build needed storage reservoirs along the main stem met with defeat from the torrential run-offs following heavy storms. The brush diversions

installed near Joseph City and Winslow needed to be replaced following every flash flood. Finally, in 1886, the first permanent storage dam on the Little Colorado River--Slough Reservoir--near the present community of St. Johns, was finished by the Mormon farmers at a cost of $200,000. This structure washed out twice in 1903 and again in 1915. Later, the dam now known as Lyman Dam, was constructed more firmly and has successfully withstood all subsequent floods. Irrigation along the Little Colorado continues today much as it was during the early settlement of the basin.

PHYSICAL DESCRIPTION

The Little Colorado River Basin occupies an ovate area of northeastern Arizona and northwestern New Mexico lying immediately west of the Continental Divide. The basin area measures approximately 250 miles in length, 150 miles in width, and includes 27,800 square miles. Approximately four-fifths (22,100 square miles) of the basin is in the State of Arizona and about one-fourth of the area (6,100 square miles) lies within the Hopi and Navajo Indian Reservations. National Forests and Monuments comprise an additional acreage of considerable magnitude.

Most of the southern and western borders of the basin are formed by the mountains of the Mogollon Rim--the highest point being 12,611-foot Humphreys Peak near Flagstaff, Arizona. The basin proper consists of a gently sloping desert plateau descending in elevation from about 8,000 feet to 5,000 feet above sea level. The plateau is broken intermittently by isolated volcanic ridges, plugs, and mesas. The lowest point of the basin is at the confluence of the Little Colorado with the Colorado River at elevation 2,712. These two rivers converge in a deep canyon 3,500 feet below the surrounding plateau at the eastern end of the Grand Canyon National Park.

The Little Colorado River rises at an elevation of about 11,000 feet in mountainous country just west of the Arizona-New Mexico border. The river flows generally northwesterly for 315 miles, with a total fall of 8,300 feet, to its junction with the Colorado. Stream gradients vary from a maximum exceeding 270 feet per mile in the headwaters to less than 3 feet per mile through most of the desert plateau above Grand Falls at River Mile 97. In the canyon reaches below Grand Falls, the gradients again increase to as much as 25 feet per mile.

Hydrologically, the Little Colorado River yields the lowest runoff per unit area of watershed of any major river in the United States. The average annual discharge of the Little Colorado is estimated at only 338,000 acre-feet in spite of the fact that the contributing drainage basin encompasses almost 28,000 square miles. These data exclude flows from several large springs recently discovered in the bed of the river about 15 miles above its mouth. The combined flows from these springs is estimated at several hundred cubic feet per second of highly mineralized water.

As shown by the data in Table I, the Little Colorado River has perennial flow only between the headwaters and Lyman Reservoir at River Mile 264--a reach of approximately 50 miles. The river is brought virtually under complete control at Lyman Dam as evidenced by the fact that an uncontrolled spill has occurred at the dam on only 40 days during the past 20 years. At Holbrook, River Mile 191, the stream bed

is dry on many days of a normal year. Near Joseph City, six miles below Holbrook, an impervious rock formation forces the underground waters to the surface. At this point, virtually all but flood flows are diverted for irrigation. Below Joseph City, the variations in river flowsbecome more extreme--flash floods may carry great volumes of water and the periods of zero flow are prolonged. At Grand Falls, River Mile 96, flash floods of 120,000 second-feet have occurred yet the number of days of zero flow per year average 120 at the same location.

The longest single tributary drainage of the Little Colorado is that of the Puerco River, an interstate stream joining the main stem from the east at River Mile 194. Although this stream and its tributaries drain a comparatively large watershed, all are intermittent over their entire length.

The Zuni River, also an interstate stream entering the Little Colorado from the east, is a relatively productive source of local irrigation water. Owing to extremely high channel losses and evaporation, however, only a very small part of the estimated 17,500 acre-feet of water carried by this stream into Arizona from New Mexico ever reaches the Little Colorado.

The most important tributaries of the Little Colorado are those originating along the Mogollon Rim and flowing northward to the main stem. These tributaries include Chevalon Creek, Clear Creek, Silver Creek, and Salt Creek. All of these tributaries are fed by the melting snows of the Mogollon Rim mountains and most would be perennial over their entire length were it not for storage reservoirs and diversions for irrigation.

Many very large dry washes also enter the Little Colorado River, each of which drains an extensive area and may discharge great quantities of water and silt during infrequent flash floods. These intermittent washes include Moenkopi Wash, Dinnebito Wash, Corn Creek, Cottonwood Wash, Leroux Wash, and Carrizo Wash leading to the Little Colorado and Black Creek which drains into the Puerco River.

The climate of the Little Colorado Basin is temperate and arid. The mean annual temperatures vary more or less inversely with altitude: the extremes recorded being 43.1° at Fort Valley (elevation 7,347) and 55.5° at Tuba City (elevation 4,325). The range of maximum temperatures varies between 98° recorded at Gallup, New Mexico, and 110° recorded at Tuba City, Arizona. Winter temperatures of -33° have been recorded in the basin. Perhaps the most striking feature of the climate is the exceptional amount of sunshine which, for the State of Arizona as a whole, averages 222 clear days annually and for the Little Colorado Basin is between 75 and 80 percent of the total possible sunshine.

Rainfall over the Little Colorado River Basin is very light and varies, more or less in direct proportion to altitude. The extremes of average annual rainfall recorded within the basin are a maximum of 18.42 inches at Flagstaff and a minimum of 6.7 inches at Tuba City. Higher rainfall occurs in the mountainous areas but is not recorded. The precipitation develops in two quite definite seasons. Snow and moderate rains may develop over the entire basin between November and March. A second wet season occurs during the summer months when highly localized rains, often of cloudburst intensity, may occur in any part of the basin. It is these latter rainfalls of one to six inches within an hour or two that bring torrential, though brief, gushes of water down arroyos that may have been dry for years. A rushing wall of water, 15 to 20 feet in height, has been observed to develop in a dry arroyo within seconds after a violent summer thunderstorm descended upon the watershed.

In comparison with the relatively low annual rainfall, the annual evaporation rate is extremely high--being estimated by the Weather Bureau at 57 inches annually as a basin-wide average. The annual evaporation measured by open pan at Lee's Ferry--just downstream from the confluence of the Colorado and Little Colorado Rivers--averages 89.90 inches. The low rainfall in an extremely arid climate, together with the complicating factors of sparse vegetation and an easily compacted soil surface which will not quickly absorb water, combine to produce the rapidly fluctuating and often intermittent stream discharge pattern characteristic of the Little Colorado River Basin.

Most of the soil of the basin is of average fertility and good crops are raised where water is available for irrigation. There are, however, extensive areas along the main-stem valley floor where the soil is deficient in humus. Alkali also is present in many sections of the main-stem Little Colorado River.

The southern rim of the basin is typical of southwestern mountain and high plateau areas with the vegetal covering increasing at higher elevations. The vegetation varies from exceedingly scant growth of grasses, sagebrush, and scrub juniper at the lower elevations to commercial stands of fir and yellow pine along the Mogollon Rim and in the White and San Francisco Mountains. Most of the basin flatlands once were grassy plains but some are now quite bare of useful vegetation as a result of overgrazing since the arrival of the white man.

TABLE I

HYDROLOGY DATA - LITTLE COLORADO RIVER

Water Years 1940-1949 Inclusive

	Total Run-off (acre-ft.)	Daily Flow (c.f.s.) Maximum	Minimum	Days of No Flow	Mean Monthly Discharge in Second-feet: Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
					Above Lyman Reservoir River Mile 268 Drainage Area 747 square miles											
Max	50,010	16,000	0.1	0	32.9	12.0	21.2	38.9	26.8	73.7	223.0	374.0	41.0	101.0	95.2	105.0
Mean	17,876*				8.9*	6.2*	9.5*	12.8*	12.1*	20.9*	87.8	49.6	10.4	19.6	32.9	18.0
Min	9,730				2.0	2.6	5.5	7.3	7.6	5.1	2.1	3.2	3.7	2.7	2.7	1.0
					Below Lyman Reservoir River Mile 264 Drainage Area 790 square miles 1/											
Max	3,470	603 2/	0.05	180	1.8	1.5	0.7	0.7	0.6	0.6	7.5	181 3/	23.2	23.7	10.5	8.0
Mean	2,130			57*	0.8*	0.4*	0.4*	0.2*	0.2*	0.2*	3.1**	28**	8.4**	6.8**	5.8**	4.4**
Min	1,140			.10	0.2	0.1	0.1	0.1	0.1	0.1	0.9	1.9	2.9	0.9	3.0	2.2
					Near Woodruff, River Mile 202 Drainage Area 8,100 square miles											
Max	115,400	13,000	0.0	94	230	20.5	52.1	170	119	610	364.0	252.0	12.4	238.0	453.0	269.0
Mean	41,146			31	46.9	9.8	14.4	33.5	30.0	98.7	47.8	26.7	2.6	69.2	208.5	76.4
Min	14,560			90	3.5	5.2	5.7	6.4	8.5	4.2	0.6	0.0	0.0	0.5	21.2	1.3
					At Grand Falls, River Mile 96 Drainage Area 21,200 square miles											
Max	586,800	20,100	0.0	203	875.0	244.0	468.0	922.0	1,349	2,223	1,809	1,405	66.6	217.0	1,211	865.0
Mean	188,701			120	226.5	51.3	69.9	146.6	232.0	608.8	776.2	234.4	6.8	82.9	446.3	243.5
Min	49,810			49	0.0	0.0	0.0	4.7	6.2	8.1	0.6	0.0	0.0	0.0	0.0	0.0
					At Cameron, River Mile 45 Drainage Area 26,500 square miles 3/											
Max	287,300	21,900	0.0	88	1,226	36.6	33.7	298.0	246.0	1,580	1,309	97.8	28.3	191.0	1,696	339.0
Mean	244,200			62	649.2	24.2	25.1	175.8	179.0	945.0	1,220	55.9	14.4	92.1	899.0	176.7
Min	201,100			36	72.3	11.9	16.6	53.7	112.0	310.0	1,132	13.9	0.0	0.0	328.0	10.0

* Data from eight years only.

** Data from nine years only.

1/ River under complete control at this point except for very infrequent flood crests. Discharge data do not include water diverted into irrigation canal at this point.

2/ Data include 546 second feet of water accidentally spilled on May 8, 1941.

3/ Data available for two years only.

ECONOMIC DEVELOPMENT

Aside from increased production of range land livestock and a marked population growth in the four major cities, the Little Colorado River Basin has changed comparatively little since the early-day Mormon colonization. The basin population still remains very sparse as evidenced by a density estimated at about three inhabitants per square mile in contrast to a national average of about 45. Very little industry has developed within the basin owing to the isolated location of area and to a general lack of basic raw materials including water.

Most of the basin population concentrated in four areas where water and/or transportation was available. The population of the principal communities of the Little Colorado River Basin, as revealed by the past three national censuses, is as follows:

Area and Community	1930	1940	1950	Percent Change 1940-50
San Francisco Mountains:				
Flagstaff, Arizona	3,891	5,080	6,771	33.3
Little Colorado River:				
Winslow, Arizona	2,700	4,577	6,518	42.4
Joseph City, Arizona	400			
Holbrook, Arizona	1,115	1,184	2,336	97.3
St. Johns, Arizona	1,300	1,656	1,469	11.3
Springerville, Arizona	575	786	689	12.3
Eager, Arizona	400	756	637	15.7
Silver Creek:				
Snowflake, Arizona	659	879	929	5.7
Puerco River:				
Gallup, New Mexico	5,992	7,041	9,133	29.7

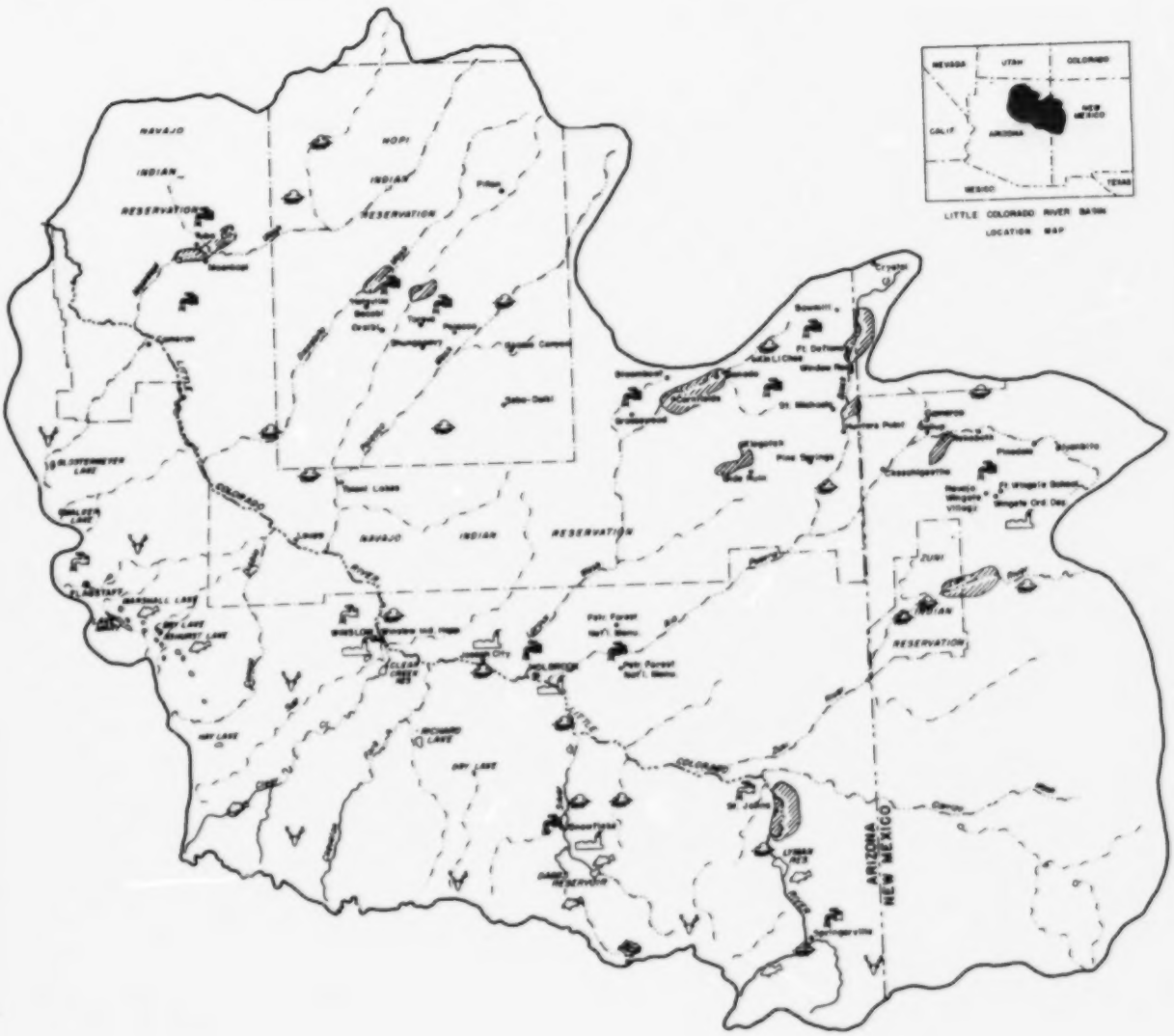
The basic production activities of the Little Colorado Basin are farming and stock raising. Although most of the lands within the basin are extensively grazed by livestock, the scarcity of water definitely limits the amount of land that can be profitably cultivated. There is some evidence that the amount of land now under cultivation, which totals approximately 0.3 percent of the basin area, is larger than is warranted by the amount of water now available.

Lumber and lumber products constitute the principal products of industry. The manufacture of jewelry, clothing, toys, and trinkets by Indians for export and for direct sale to tourists represents an industry of considerable magnitude. Food processing is of some importance within the basin as is the production of stone and clay products. Coal mining

at one time was a very important basin industry around Gallup, New Mexico. With the increasing use of oil for locomotive fuel by the Santa Fe Railroad and the recent entrance of natural gas into the fuel picture, coal production has become a negligible item in the basin economy in spite of the enormous coal reserves. Tourist service and trade constitute, by far, the greatest single source of revenue within the basin.

The Little Colorado Basin is traversed by U. S. Highway 66, often called the "Main Street of America" in that it carries more transcontinental motor traffic than any other highway. This highway parallels the Santa Fe Railroad across the basin and the cities of Gallup, Holbrook, Winslow, and Flagstaff--which developed as service points for the railroad--now are largely dependent upon a motor tourist trade economy. Highway 66 west of Flagstaff in 1950 carried the heaviest volume of interurban motor traffic of any highway in the State of Arizona. During that year, 763,000 motor vehicles were estimated to have travelled this section of all-weather highway and of these, 535,000--or 70 percent--were out-of-state registration. The principal tourist attractions within the basin area are the spectacular unique scenery and the indigenous Navajo, Hopi, and Zuni Indian cultures.

The basin area also is served by main-line flights of Trans-World Airlines and by the regional Bonanza and Frontier Air Lines.



DOMESTIC WATER SUPPLY
(Surface water use presumed in areas)

DOMESTIC WATER SUPPLY
(Ground water use presumed in areas)

DOMESTIC WATER SUPPLY
(Combination ground and surface water use presumed in areas)

INDUSTRIAL WATER SUPPLY

WILDLIFE

IRRIGATION (also cross-hatched areas)

FISH HATCHERY

GAME FISHING

SCALE OF MILES
0 5 0 5 10

LITTLE COLORADO RIVER BASIN

EXISTING PRIMARY WATER USES

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

Public Health Service
DIVISION OF WATER POLLUTION CONTROL
MAP NO. 1

EPO 888788

USES OF WATER RESOURCES

Waters of the Little Colorado River Basin are used almost exclusively for municipal supplies, irrigation, and lifestock watering. With but one or two minor exceptions, all water is obtained directly from surface or underground sources. No concerted effort has been made to reclaim sewage treatment plant effluents which are allowed to seep back into the ground unutilized in spite of the critical water needs of the area and the cost of pumping underground water from depths sometimes exceeding one thousand feet.

In any climate so arid as that of the Little Colorado Basin, the scientific conservation and utilization of all waters are vital to economic existance. Water conservation by storage of stream flows in reservoirs during the rainy seasons and the full utilization of the few perennial streams by diversion for irrigation have been practiced since the first settlement by the white man and, in but slightly lesser degree, by the Indians long before them.

There are many reservoirs, most of them small, on the headwaters of the Little Colorado and its more important tributaries. Twenty-six reservoirs exceeding 500 acre-feet in capacity have been constructed within the basin with a combined total capacity of about 95,000 acre-feet. There are also numerous smaller reservoirs, often called "tanks," usually of considerably less than 500 acre-feet capacity that are used to store water for livestock and irrigation. Complete data are lacking, but it is estimated that the total combined water storage capacity of all reservoirs, large and small, within the Little Colorado Basin approximates 165,000 acre-feet.

Lyman Reservoir, on the site of the original Slough Reservoir near St. Johns, is the largest impoundment in the basin with a storage capacity of 21,900 acre-feet. This reservoir serves primarily for the impoundment of irrigation water although the community of St. Johns does use some reservoir water to supplement its spring-water domestic water supply. Lake Mary and Upper Lake Mary, impoundments of 18,900 and 16,576 acre-feet respectively on Walnut Creek--a headwater tributary of Canyon Diablo--provide supplemental municipal water for the city of Flagstaff. Rascad and Ramah, impoundments of Zuni River of 8,720 and 1,170 acre-feet respectively, also provide domestic water to Indian installations. The impounded waters of lower Clear Creek serve as a municipal supply for the city of Winslow. All other reservoirs within the basin serve primarily for the impoundment of irrigation water.

Most communities in the basin, other than those mentioned in the preceeding paragraph, tap underground sources for domestic water supplies. Although numerically, most communities of the basin use

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underground water, nevertheless, from the standpoint of total quantity used, the surface supplies of the basin furnish the bulk of domestic water.

Municipal water use within the Little Colorado River Basin, as indicated by July 1952 data, is listed in the following table:

Municipality	Est. Pop. Served	Source of Supply	Rated Capacity m.g.d.	Average Output m.g.d.	Treatment
New Mexico:					
Fence Lake	200	Deep Well		0.012	
Gallup	7,500	Deep Wells	1.2		So-CO-Se-Flt-Chl
Navajo Wingate Village	300	Deep Wells			
Pietown	60	Deep Well			
Quemado	150	Deep Well	0.01	0.004	
Ramah	120	Deep Well			
Wingate Ordnance Depot	800	Deep Wells	0.05	0.015	
Arizona:					
Eager	800	Sur.& Sprgs.			None
Flagstaff	11,000	Sur.& Sprgs.	1.33	1.0	CO-Se-Flt-Chl
Fort Defiance	1,500	Wells	0.265	0.105	Chl
Ganado	400	Wells	0.015	0.03	None
Heber	250	Deep Wells		0.01	
Holbrook	4,000	Deep Wells	0.43	0.27	Chl
Joseph City	250	Deep Wells	0.15	0.05	
Keams Canyon	600	Wells	0.046	0.046	None
Lakeside	500	Spr.& Well	0.10	0.04	
Lupton	100	Well			
Overguard	500	Well			
Petrified Forest Nat'l. Mon.		Well	0.024	0.008	
Pinedale	80	Well	0.014		
Pinetop	150	Spring			
Showlow	600	Well	0.02	0.02	
Snowflake	950	Deep Wells	0.072	0.009	None
St. Johns	1,400	Sur.& Sprgs.	1.35		Chl-Flt-Chl
Tuba City	850	Combination	0.024	0.011	None
Taylor	500	Well			
Window Rock	360	Well	0.065	0.044	None
Winslow	9,000	Surface	1.35	0.76	Se-Flt-Chl

So--Softening Flt--Filtration
Co--Coagulation Se--Sedimentation Chl--Chlorination

The average output data and population served indicate a basin-wide per capita use of about 88 gallons per day. Summertime use probably is considerably greater than this figure indicates.

Except for irrigation, comparatively little water is used for industrial purposes within the basin. The Santa Fe Railroad has several deep wells along their right-of-way which formerly supplied water for steam locomotives. With the increasing use of diesel-electric motive power by the railroad, very little locomotive water now is being used. The Santa Fe Railroad wells at Gallup, New Mexico, were purchased by the City early in 1953 to relieve the critical shortage of municipal water that has developed during the past few summers.

Some small hydroelectric power plants have been installed in the headwater areas of the Little Colorado and its tributaries to provide light and power for local consumption. The limited quantity of available water and the extreme variations of stream flow, coupled with the high seasonal demands for irrigation water, have discouraged any large-scale hydroelectric power development within the basin.

The recreational use of water is limited to the short reaches of perennial streams, mostly along the Mogollon Rim, that support trout fishing, as do several of the high mountain irrigation water impoundments southeast of Flagstaff. The sloping forested plateau northeast of the Mogollon Rim constitute excellent deer habitat as well as virtually the only elk range found in the State of Arizona. Antelope and deer also inhabit the desert areas where water can be found.

Range livestock are raised over most of the basin, the most productive lands being found along the slopes of the Mogollon Rim extending northeasterly into New Mexico. Water for livestock generally is pumped from underground sources into small isolated "tanks" of less than five acre-feet capacity.

Farming is another basic industry of the Little Colorado Sub-Basin being most intensively practiced in the headwater areas of the main stem, along the Zuni River, and in the upper Silver Creek drainage where surface water is available for irrigation. Other cultivated areas are widely scattered over the basin wherever surface water is available for irrigation--many being Indian subsistence farms.

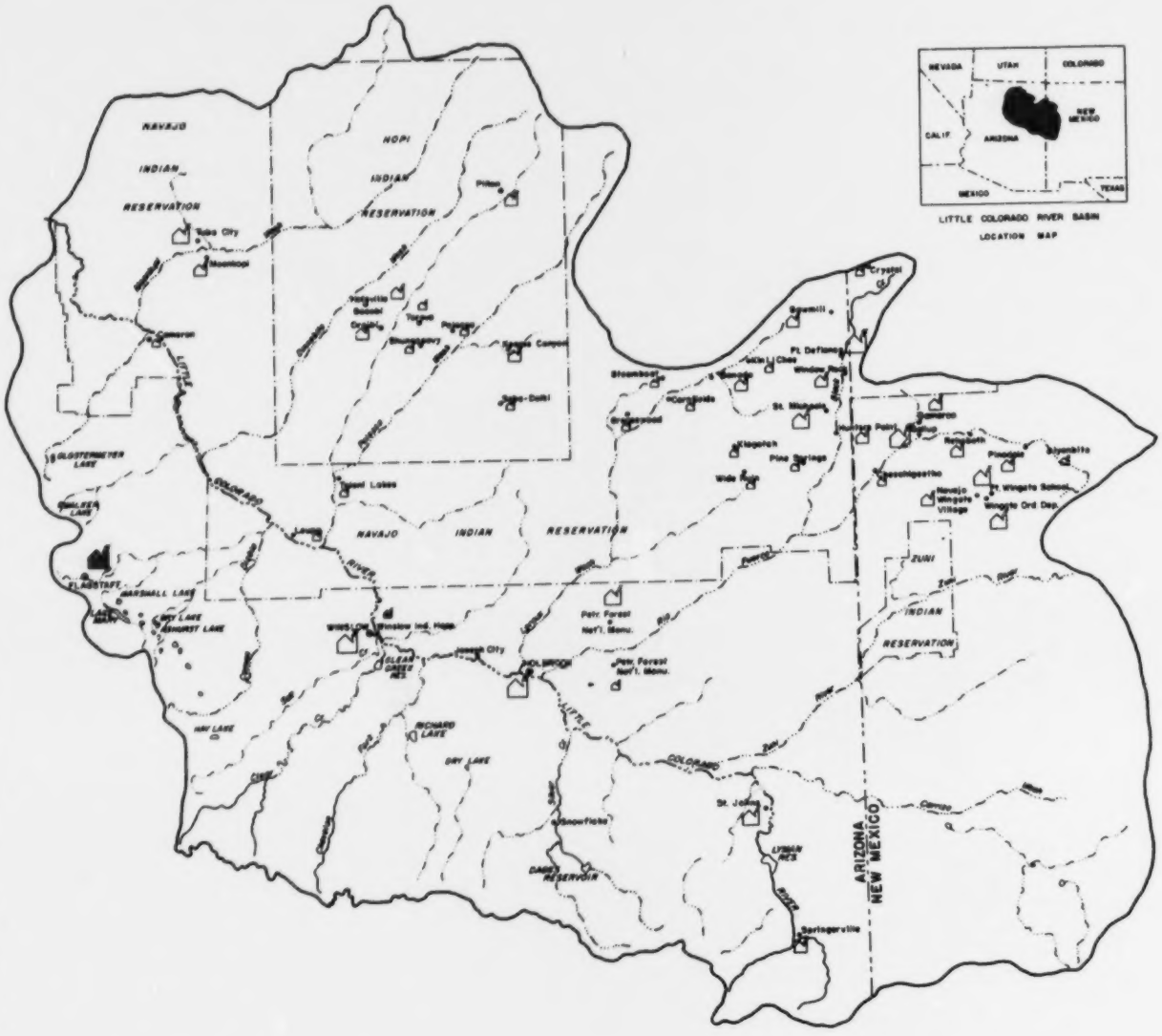
The distribution of irrigated lands of the Little Colorado River Basin in 1945, and which presumably has changed little since, was as follows:

Area	Acreage under irrigation
Headwaters, above St. John	15,180
Upper Zuni River	6,770
Silver Creek Basin	4,360
Holbrook-St. Joseph	1,520
Winslow	610
Woodruff (near Holbrook)	520
Scattered areas	19,040
Total for basin	48,000

Some dry farming of minimum water crops--principally pinto beans--is practiced in a few isolated areas of the basin that receive sufficient rainfall. Most of the dry farming area is found in the vicinity of Flagstaff. The limited quantity of water available for irrigation in the basin is vividly emphasized in that, with all suitable firm water being utilized, less than 0.3 percent of the basin area is under cultivation.

Very limited quantities of underground water are used for irrigation and these mostly in the upper basin area where some wells have been pumped for over 40 years. The underground water resources have not been fully explored.

The principal crops raised in the basin are corn, wheat, alfalfa, and dry edible beans. Some vegetables are grown near Springerville for commercial markets.


NAVAJO
INDIAN
RESERVATION
HOPI
INDIAN
RESERVATION
Tuba City
Moenkopi
Cameron
Winslow
Holbrook
Petr. Forest Nat'l. Mon.
Petr. Forest Nat'l. Mon.
Joseph City
Clear Creek Res.
Meteor Crater
Canyon Diablo
Leupp
Dilkon
Indian Wells
Kayenta
Chinle
Ganado
Window Rock
Fort Defiance
Chambers
Sanders
Navajo Mission
Round Rock
Many Farms
Rough Rock
Pinon
Klagetoh
Wide Ruins
Greasewood
Sawmill
Crystal
Ft. Wingate
Ft. Wingate Ord Dep.
Navajo Wingate Village
Pine Springs
Houck
Lukachukai
Rock Point
Red Rock
Tsaile
Lukachukai
Round Valley
Low Mountain
Chilchinbito
Cornfields
Greasewood
Blue Gap
Tachee
Jeddito
Polacca
Keams Canyon
Second Mesa
Oraibi
Hotevilla
Shungopavy
Toreva
Polacca
Kykotsmovi
Hotevilla
Bacavi
Sipaulovi
Shipaulovi
Moenkopi
Tuba City
Cameron
Little Colorado River
Colorado River
Navajo Indian Reservation
Hopi Indian Reservation
Zuni Indian Reservation
Zuni River
Puerco River
Chevelon Creek
Silver Creek
Show Low Creek
Carrizo Creek
Chevelon Canyon
Clear Creek
Dry Lake
Richard Lake
Hay Lake
Marshall Lake
Ghostrider Lake
Bluewater Lake
Bonito Lake
Black Lake
Ramah Lake
Whiteriver Lake
Whitecone Lake
Big Lake
Horseshoe Lake
Silver Lake
Bonito

POLLUTION CONTRIBUTED TO WATER RESOURCES

Salts and sediment from natural sources constitute the most damaging pollutants to the waters of the Little Colorado River Basin.

Surface water flows are, for the most part, of good chemical quality near their points of origin. As indicated by the data outlined in Table II, the main-stem water progressing downstream rapidly acquires a heavy salt burden (see items 1 to 5, Table II) as it flows over formations high in soluble salts. Mineral springs in places also contribute large quantities of dissolved solids (see items 5 and 6, Table II) to the stream.

The chemical quality of the limited underground waters of the basin varies widely in different areas. Analyses show that waters from different wells vary between 100 and 6,000 parts per million of dissolved solids. Generally speaking, the wells yielding the poorest quality of water, chemically, are found in the shale-sandstone formations and in the sands and gravel of Cottonwood Wash, Leroux Wash, and the Little Colorado River bottom lands.

Nearly all streams of the Little Colorado Basin carry large amounts of sediment, particularly during floods when the flows may actually contain more solids than liquids. The only exceptions are the upper reaches of the streams originating along the Mogollon Rim. These streams receive most of their charge from melting snows and flows are comparatively uniform during the year. The other streams of the basin are sharply affected by precipitation. Local flood crests often develop following summer cloudbursts. The loose soil and sparse vegetal cover, characteristic of much of the basin area, offer little resistance to erosion which is severe throughout the basin.

According to data of the U. S. Geological Survey, the Little Colorado River carried 14,280,000 tons of sediment past Cameron (River Mile 42) during 1949 and 3,355,000 tons during 1950. These data indicate that soil loss from the Little Colorado Basin in the form of waterborne sediment reaching Cameron during 1949 and 1950 was approximately equivalent to removing 400 and 125 tons of soil, respectively, from each of the 26,500 square miles of contributing watershed.

Insofar as man-made domestic wastes are concerned, available data as listed in Tables A and B show that but 2 of the 45 sewered communities and institutions in the Little Colorado River Basin lack some form of waste treatment. The only sewered community lacking sewage treatment is Flagstaff, Arizona, which currently discharges its sewage raw into Sewer Canyon--a dry wash tributary to San Francisco Wash. Also, the Office of Indian Affairs' hospital at Winslow, Arizona, discharges untreated wastes into a pipeline carrying raw sanitary wastes from the Santa Fe Railroad shops to a marginal slough of the Little Colorado River.

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TABLE II

ANALYSES OF LITTLE COLORADO BASIN WATERS

February 5-11, 1943

(In parts per million unless otherwise specified)

Sampling Point	Approx. River* Mile	Discharge cfs	Sp.Conduct. ($Kx10^{-5}$@25°)	SiO_2	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	Dissolved ppm	Solids tons/ ac.ft.	Total Hardness as $CaCO_3$	%Na
Little Colorado near Eager	287		24.6	28	28	11	15		162	7	4.0	0.2	0.4	174	0.24	115	22
Little Colorado near Springerville	285		36.7						250	7.2	5.0						
Little Colorado above Lyman Reservoir	268	4	50.2	24	44	21	47		308	23	15	0.2	0.1	326	0.44	196	34
Little Colorado below Lyman Reservoir	264	0.1	53.2		48	19	52		294	44	17		0.2	325	0.44	198	36
Little Colorado near St. Johns above Salado Springs	260		177	19	154	48	205		468	346	198	1.7	0.4	1,203	1.64	582	43
Little Colorado near St. Johns below Salado Springs	258		311	17	262	67	411		618	698	415	1.8	0.3	2,177	2.96	930	49
Little Colorado at St. Johns	255		301	14	199	70	434		434	714	442	1.7	0.4	2,089	2.84	784	55
Little Colorado at Hunt Gage		0.3	259	11	126	37	411		258	393	522	0.4	1.1	1,629	2.22	466	66
Zuni River Enters Zuni River near Hunts	ZR0.5		621	12	251	81	973		344	547	1,575	0.4	2.5	3,610	4.91	960	69

Silver Creek Enters	205														
Silver Creek near Woodruff	SC0.5	6	49.0	16	46	23	45	268	57	20	0.1	339	0.46	210	32
Little Colorado near Woodruff		7	51.2		46	13	46	240	59	24	0.3	312	0.42	193	34
Puerco River Enters	194														
Puerco River near Adamana		3	105	14	54	13	174	240	247	75	8.4	704	0.96	188	67
Chevlon Creek Enters															
Chevlon Creek near Winslow	CC-3	22	60.7		24	11	91	100	29	.135	0.2	340	0.46	105	65
Clear Creek Enters															
Clear Creek near Winslow	CC-1.5		222					234		595	0.1				
Little Colorado at Grand Falls	96	41	189	11	46	12	352	210	160	418	0.4	1.1	1,014	1.50	164	82

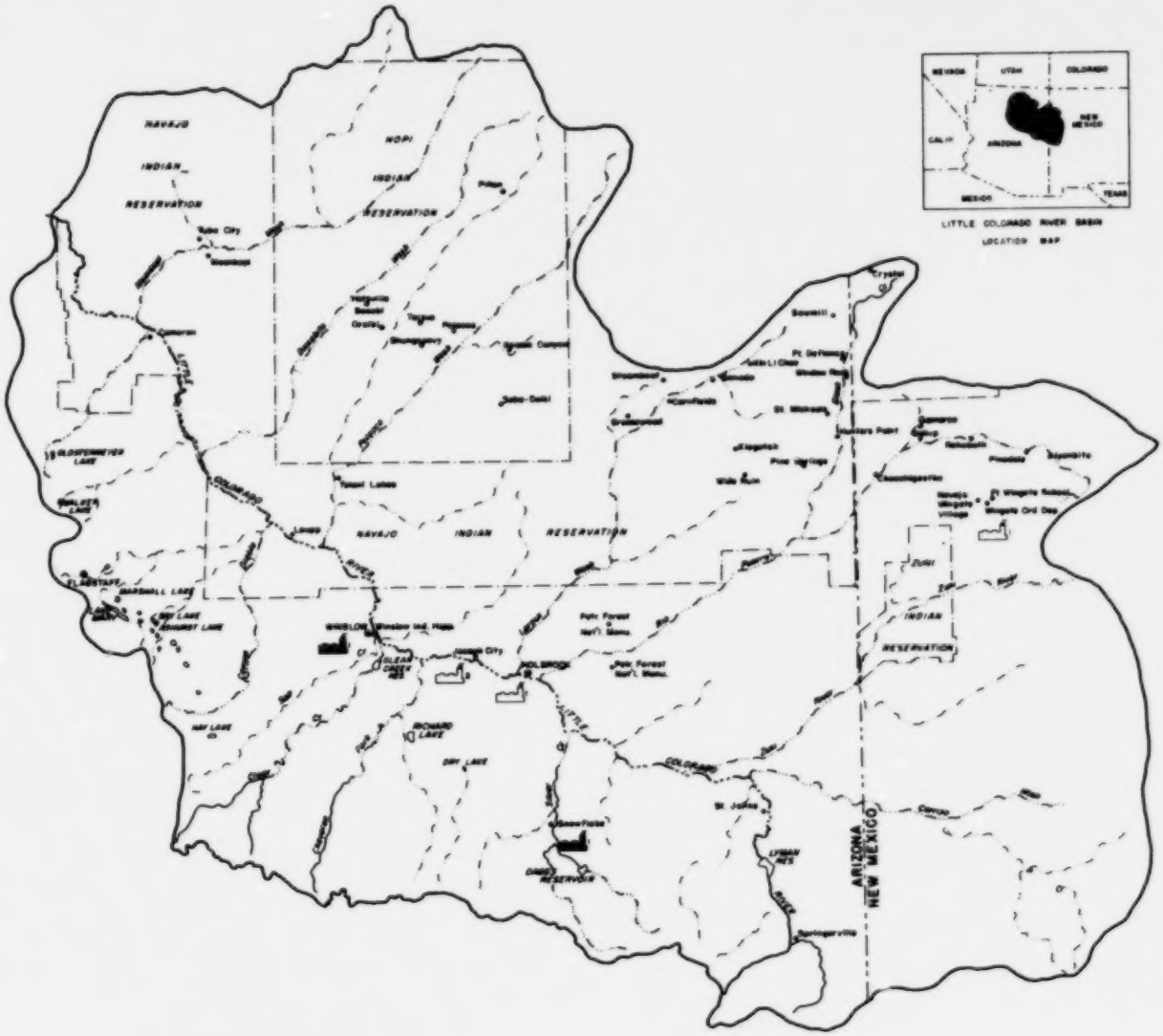
Data obtained from Geological Survey Water Supply Paper 970, "Quality of Surface Waters of the United States." U. S. Geological Survey, 1943 (1945).

* River miles from confluence of Little Colorado and Colorado Rivers for main-stem locations or from junction with Little Colorado River in case of tributary locations.

Most of the domestic waste treatment facilities within the basin are of the primary type although a higher degree of waste treatment is provided to a slightly greater population at the 14 secondary treatment plants of the basin (see Table B). Although 43 of the 45 sewered communities within the basin provide some degree of waste treatment, State Health authorities consider only 9 of the 43 sewage treatment plants as having sufficient capacity to meet current loads and only 7 of the 43 plants are being operated satisfactorily. There are but 6 plants in the basin where both capacity and operations are considered as entirely satisfactory.

In addition to the pollution contributed from the sewered communities, there are several unsewered communities within the basin, as well as unsewered fringe areas about several of the larger municipalities, which State Health authorities believe may be polluting the basin waters. These unsewered areas are considered in Appendix II of this report.

Industrial wastes constitute a very minor pollution problem in the Little Colorado River Basin. The data listed in Tables B, D, and 2 (Appendix I) show the known basin industries with waterborne wastes that are not discharged into municipal sewers. Satisfactory treatment facilities are lacking for processing wastes from three small dairies and shop wastes from the Santa Fe Railroad installations at Winslow, Arizona.



INDUSTRIES WITH TREATMENT FACILITIES

INDUSTRIES WITH TREATMENT FACILITIES UNDETERMINED

INDUSTRIES WITH NO TREATMENT FACILITIES

NOTE: Numbers appearing by symbols indicate total number of industrial sources of pollution in the area in the category designated

SCALE OF MILES

LITTLE COLORADO RIVER BASIN
SOURCES OF INDUSTRIAL POLLUTION
AND
EXISTING TREATMENT FACILITIES
DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Public Health Service
DIVISION OF WATER POLLUTION CONTROL
MAP NO 3

GPO 868752

TABLE A
SOURCES OF POLLUTION
MUNICIPAL
April 1953

Municipalities*	Sources of Pollution (In Number of Municipalities*)	Population Served by Sewerage System	Amount of Pollution Discharged to Watercourse (In Terms of Equivalent Number of People)**
Having data on pollution load discharged to watercourse	0	-	-
Having population data available (Data on pollution load to watercourse incomplete or not available)	45	35,055	Undetermined
TOTAL	45	35,055	

* Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers or other population centers.

** Includes industrial wastes discharged into municipal sewerage systems.

TABLE B
SOURCES OF POLLUTION
INDUSTRIAL*
April 1953

Industries*	Sources of Pollution (In Number of Plants)	Estimated Amount of Pollution Discharged to Watercourse (In Terms of Equivalent Number of People).
Producing Organic Wastes	4	26
Producing Organic Wastes	2	Undetermined
Producing Inorganic Wastes	0	
Producing Wastes of Undetermined Type	0	
TOTAL	6	

* Industries having separate outlets discharging wastes directly to watercourse.

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DAMAGES TO THE WATER RESOURCES FROM POLLUTION

The most damaging pollutants of the Little Colorado River Basin are the natural salts and sediment. Domestic waste pollution, where it occurs, is highly localized by the intermittent character of most surface waters and the geographical distances between centers of population. The very few industrial waste problems of the basin are important only as they constitute a local nuisance.

According to the Bureau of Reclamation, dissolved salts from natural sources often become sufficiently high in the main-stem Little Colorado River below the Holbrook-Joseph City area to exceed tolerance limits for both domestic and agricultural uses. Between St. Johns and Holbrook, the main-stem water may be of questionable quality for irrigation during certain seasons of the year. Dissolved solids likewise preclude use of some underground waters for either irrigation or domestic purposes.

The tremendous sediment loads carried at times by streams of the basin greatly reduce, or eliminate entirely, recreational use of the stream reaches affected. Sediment dropped as flood charges recede aggrade the stream beds and thus complicate and greatly increase the cost of flood protection for adjacent lands, railroad and highway bridges. Sediment deposits likewise aggrade irrigation waterways and necessitate frequent and expensive dredging of both irrigation and drainage canals. Many small reservoirs constructed in the desert area of the basin have filled with silt within a very short time and many local residents are fully convinced by experience that water storage reservoirs on desert streams are infeasible solely because of the heavy sediment burdens of the waters. Zuni Reservoir, an irrigation-water impoundment of Zuni River near the New Mexico-Arizona border, is the only reservoir of the Little Colorado Basin that has been subjected to long-term sedimentation studies. When completed in 1906, Zuni Reservoir had a storage capacity of 10,230 acre-feet. By 1928, sedimentation had reduced the live storage of the reservoir at the same elevation to 525 acre-feet--a reduction of 95 percent in storage capacity within a 22-year period.

Damages to the water resources created by domestic wastes tend to be highly localized for a continuous flow of water from one population center to another seldom exists in the Little Colorado Basin. Lacking flowing water for either the dilution or transportation of wastes, an unsatisfactory sewage plant effluent, which represents the concentrated wastes from a relatively large number of individuals, constitutes a definite public health hazard. This is particularly true under arid conditions such as prevail in the Little Colorado Basin where competition for available water greatly lessens the concern over sanitary quality that is generally held in better-watered areas.

Ineffectual protection of public health also is provided by the individual waste disposal facilities found in the larger unsewered communities and in certain fringe areas that have developed about some of the larger municipalities of the basin. In these comparatively densely populated unsewered areas, the same water strata into which the partially treated cesspool and septic tank wastes are discharged may be tapped for domestic water long before the natural purification processes can eliminate pathogenic organisms from the wastes.

Examination of the basic data for the sewered communities of the Little Colorado Basin listed in Table 1, Appendix I, reveals that 26 of the 32 domestic waste treatment plants of known unsatisfactory capacity are located on lands owned and controlled by the Federal Government. Two of the unsatisfactory plants are in the Petrified Forest National Monument, which annually attracts about 100,000 visitors, and the remaining 24 are on the Indian Reservations.

Most of the domestic waste treatment facilities at the Indian installations are septic tanks which discharge their effluent directly onto the ground surface or into intermittent streams. The disposal areas below the septic tanks are not fenced and generally are open to free access by either livestock or humans. Considering the very poor sanitary quality of septic tank effluent and the complete lack of any dilution water during the prolonged dry seasons, this method of domestic waste disposal constitutes a definite health hazard. With certain underlying porous rock formations, the sanitary quality of underground waters could be affected over a comparatively wide area.

Morbidity rates for dysentery are known to be very high among the reservation Indians--several fold those for the white population of the basin area. The Indian problem, insofar as dysentery is concerned, is basically one of sanitation. Although the degree to which water contaminated from sewered sources of domestic wastes--or from those sources where sewerage is indicated--may contribute to the health problem cannot be determined with present knowledge, the potential is high.

BENEFITS RESULTING FROM POLLUTION PREVENTION AND ABATEMENT

A higher level of public health, some additional irrigation water, and a marked reduction in soil loss with subsequent reductions in river-bed and reservoir sedimentation constitute the chief benefits to be realized from effective pollution prevention and abatement in the Little Colorado River Basin.

The contribution made to the general public health problems of the basin by waterborne diseases cannot be defined with available data. However, where an unsatisfactory level of domestic waste treatment and high dysentery rates prevail in an area where water is in such critical demand, some association between these important public health factors seems a tenable assumption. All of these conditions co-exist in the Little Colorado Basin.

The public health significance of contaminated waters of the Little Colorado Basin may well be of far wider consequence than the resident populations indicate because of the heavy tourist travel through the area. Even an isolated small school well becomes a semi-public water supply when no other source of water is available for many miles. Effective basin-wide domestic waste treatment would lessen the risk of exposure to water-borne diseases and possible widespread dissemination by a traveling public.

Unquestionably, considerable benefit to public health has accrued from the pollution control measures that have been installed. Unfortunately, available data do not permit even a reasonably accurate guess at the benefits already received or those that might be achieved.

The salvage of water through the reclamation of adequately treated sewage plant effluents also assumes greater than normal importance in the Little Colorado Basin. Although the quantity of water available from the sewage treatment plants would be insignificant in better-watered areas, nevertheless even a comparatively few acres of forage crops produced by reclaimed sewage plant effluents would represent a relatively large increase in the agricultural production of the basin. Domestic wastes from the community of Flagstaff, for example, represent a potential source of about 1,000 acre-feet of irrigation water each year that currently is being wasted. A study of the possibilities of water conservation through the reclamation of sewage plant effluents is definitely in order.

The extent to which soil erosion and sedimentation can be controlled through economically feasible soil conservation measures cannot be predicted with present knowledge of the basin problems. However, the demonstration areas maintained by the Soil Conservation Service in the Little Colorado and adjoining river basins offer

convincing evidence that much can be done, economically, to hold the soil in place through realistic range management, water spreading, and reseeding. In many locations, the erosion cycle has progressed so far that more elaborate engineering structures will be required to control arroyo cutting. Any degree of practical erosion control would be beneficial in that even a partial reduction in aquatic sediment burdens would assist in prolonging the life of downstream reservoirs, reduce in some degree the annual maintenance costs for irrigation waterways, and decrease the severity of flood damage resulting from aggraded stream channels.

POLLUTION PREVENTION MEASURES IN EFFECT

The overall picture of pollution prevention measures currently in effect at the sewered municipalities and institutions within the Little Colorado Basin is given in Table 1, Appendix I.

The program of pollution control by treatment of domestic wastes from the larger and sewered communities has been well advanced by the State Health Departments of Arizona and New Mexico as evidenced by the fact that only one of the sewered communities and one institution lack some form of domestic waste treatment. In other words, all but 6,850 of the estimated total sewered population of 35,500 living within the basin are served by some form of sewage treatment (Table C). Most of the sewage treatment plants (29 of 43) provide primary treatment although the 14 secondary-treatment plants of the basin serve a slightly larger total population (Table C). The adequacy of plant capacity and the level of plant operation leave much to be desired--only 6 sewage treatment plants serving 2,800 persons are considered as entirely satisfactory by the State Health authorities.

The State of New Mexico places the responsibility for water pollution control, insofar as public health and nuisances are concerned, with the State Department of Public Health which was designated as the State Water Pollution Control Agency pursuant to the provisions of the Federal Water Pollution Control Law. Certain provisions of the New Mexico State Game Code delegate authority to enforce pollution control measures required for the protection of fish and wildlife to the State Department of Game and Fish. Other State agencies, including the Interstate Stream Commission, the Oil Conservation Commission, the Plumbing Administrative Board, and the Office of the State Engineer, also have statutes, regulations, or codes that concern the control of water pollution.

In the State of Arizona, the State Board of Health was empowered by law to set up rules and regulations to "regulate sanitation and sanitary practices in the interests of public health." These rules and regulations were administered by the State Department of Health. In addition, the State Game and Fish Commission is authorized to bring suit against anyone polluting water so that it may be injurious to fish or wildlife. The general State Code contains a provision enforceable by authorities of local subdivisions and designed to prevent pollution of water so that it might not become "unhealthful or offensive." Incorporated municipalities and full-time local health units in some cases have additional ordinances which regulate sanitary practices within their area of jurisdiction.

A recent decision by the Arizona State Supreme Court declared unconstitutional the law empowering the State Board of Health to establish

rules and regulations. In effect, this decision stripped the State Department of Health of any authority over water pollution.

A new general health law was adopted by the 21st Arizona Legislature which was designed to restore most of the former powers held by the State Board of Health. The Board was empowered to "provide reasonable minimum standards necessary for the protection of public health" and to adopt "reasonable and necessary rules and regulations to promote and provide for compliance with such minimum standards" with relation to specified subjects. Water supply, sewage disposal, excreta disposal, and industrial wastes were included in the list of subjects.

The Arizona State Board of Health recently adopted those parts of the former Sanitary Code covered by the new laws. These rules and regulations are administered by the State Department of Health.

Questions of health and sanitation on the Indian Reservations are administrative responsibilities of the Federal Government. The State Health authorities exert jurisdiction over waste treatment facilities on Indian Reservations only upon invitation by the tribal councils or by the Federal Government. Recently, the U. S. Bureau of Indian Affairs has recruited and schooled sanitarians from the various Indian tribes to work among the reservation Indians in an attempt to improve the general level of reservation sanitation.

TABLE C
EXISTING TREATMENT FACILITIES
MUNICIPAL
April 1953

Degree of Treatment Provided	Number of Municipalities* Served	Number of Treatment Plants	Population Served
Primary	29	29	13,770
Secondary	14	14	14,440
No treatment	2	-	6,845

* Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

TABLE D
EXISTING TREATMENT FACILITIES
INDUSTRIAL*
April 1953

Type Industry	Number of Plants	Number of Industrial Plants Having: Treatment Facilities	No Treatment Facilities	Undetermined Facilities
Food	4	3	1	-
Miscellaneous	2	1	1	

* Industries having separate outlets discharging wastes directly to water course.

TABLE E
ADEQUACY OF EXISTING TREATMENT FACILITIES
MUNICIPAL*
April 1953

Number of Municipal* Treatment Facilities	Adequacy With Relation To: Capacity			Operation		
	Satis-factory	Unsatis-factory	Unde-termined	Satis-factory	Unsatis-factory	Unde-termined
43	9	31	3	7	33	3

* Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

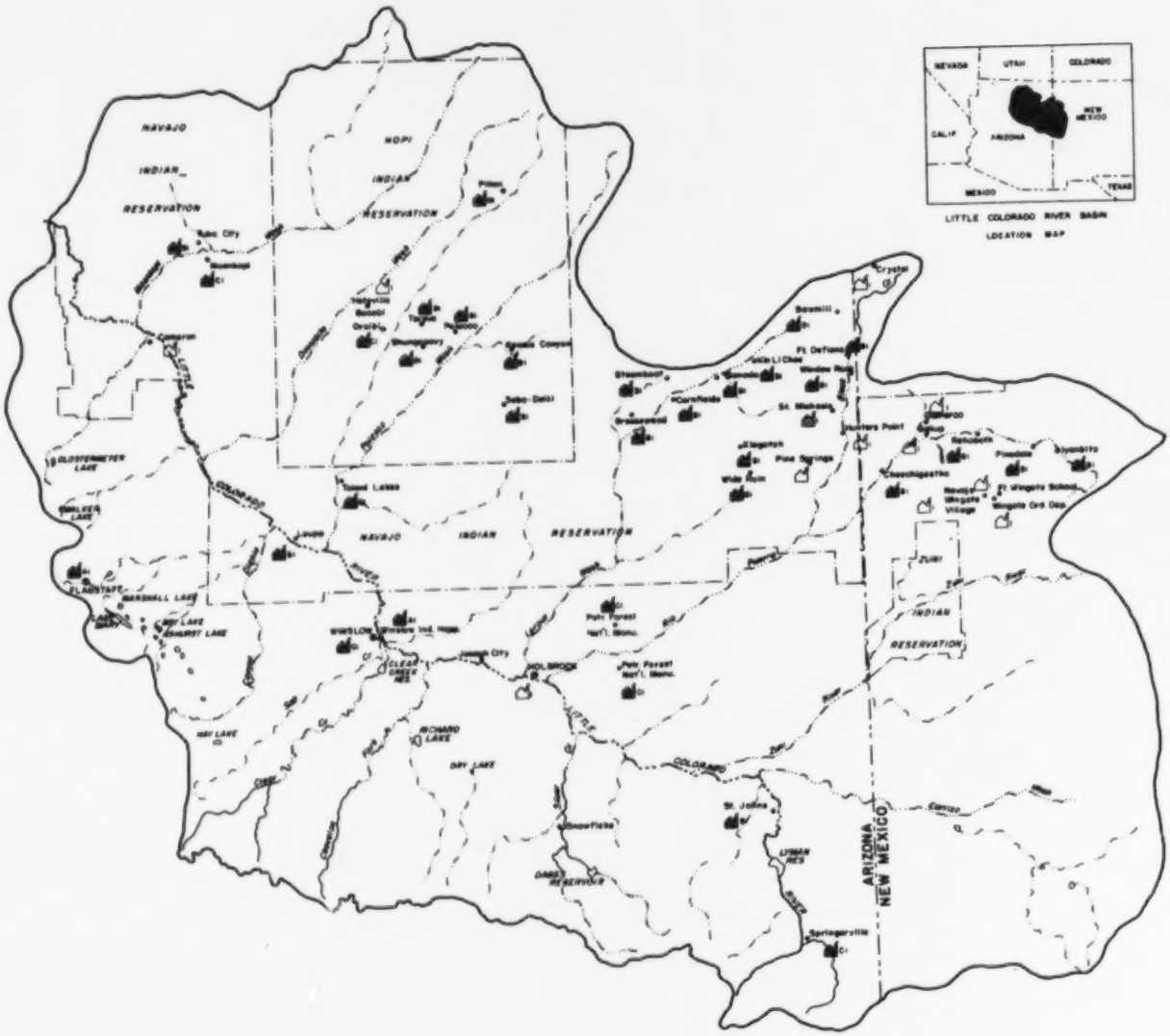
TABLE F
ADEQUACY OF EXISTING TREATMENT FACILITIES
INDUSTRIAL*
April 1953

Number of Industrial* Treatment Facilities	Adequacy With Relation To: Capacity			Operation		
	Satis-factory	Unsatis-factory	Unde-termined	Satis-factory	Unsatis-factory	Unde-termined
4	2	2	0	2	2	0

* Industries having separate outlets discharging wastes directly to watercourse.

TABLE G
PROGRESS IN CONSTRUCTION OF POLLUTION ABATEMENT FACILITIES
April 1953

	Municipal		Industrial	
Year	Sewage Treatment Plants Completed	Design Population	Waste Treatment Plants Completed	Amount of Waste Treated (In Terms of Equiv. No. People)
1946	0		N	
1947	0		0	
1948	0		N	
1949	2	5,000	E	
1950	0			
1951	0			
1952	1	500		



NO TREATMENT NEEDS

TREATMENT NEEDS UNDETERMINED

TREATMENT NEEDED

TREATMENT NEEDS INDICATED BY LETTERS APPEARING BESIDE 'TREATMENT NEEDED' SYMBOLS, AS FOLLOWS:

- A NEW PLANT
- B ENLARGEMENTS OR ADDITIONS TO EXISTING PLANT
- C REPLACE EXISTING PLANT

NOTE Numbers next to symbols or next to code letters represent number of treatment needs in the category designated

SCALE OF MILES

LITTLE COLORADO RIVER BASIN

MUNICIPAL

WASTE TREATMENT NEEDS

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

Public Health Service

DIVISION OF WATER POLLUTION CONTROL

MAP NO 4

POLLUTION PREVENTION MEASURES REQUIRED

The data in Table H reveal that an extensive program of sewage treatment plant renovation and modernization is needed in the Little Colorado River Basin. The fact that so little local action has been taken during recent years or being considered at the present time (See Tables G and J) emphasizes the need for comprehensive program of pollution abatement that can be placed before the public as a recognized and necessary policy. It should be strongly emphasized, however, that the lack of comprehensive program of pollution abatement should in no way delay the provision of any waste treatment facilities currently recognized as needed.

The specific pollution prevention and control measures required at the sewered communities and industries--which are recognized at the present time--are listed in Table L. These include 2 new sewage treatment plants, facilities for additional treatment of wastes at 25 existing plants, and the entire replacement of six existing plants. In addition, operations must be improved at 33 plants before the disposal of wastes from the sewered communities of the Little Colorado Basin can be considered as fully acceptable. At the present time, there are only 6 fully satisfactory sewage treatment plants in the basin and these serve only 4,050 people--or approximately one-eighth of the sewered population.

The cost of providing the needed facilities listed in Table L, exclusive of those on the Indian Reservations, is estimated by State Health authorities at $220,000 for municipal waste treatment and $4,000 for industrial waste treatment. It is emphasized that these cost estimates apply only to the communities that currently have waste collection systems and/or to industries known to produce a damaging effluent.

There are also within the Little Colorado Basin many communities currently unsewered at which both waste collection systems and waste treatment facilities are required. Likewise, fringe areas have developed about certain sewered communities for which extension of the municipal sewerage system is needed. In most cases, the additional burden of wastes from the fringe areas will necessitate enlargement of the treatment plant facilities. These communities have been listed according to their respective needs in Appendix II of this report.

The industrial waste problems of the Little Colorado Basin appear at this time to be of extremely minor importance (Table B).

Many of the additional waste treatment facilities required in the Little Colorado Basin are for installations operated by the Bureau of Indian Affairs, U. S. Department of the Interior and in these, the Federal Government has an extraordinary interest. Almost without exception, the facilities needed on the Indian Reservations constitute some form of secondary treatment for oxidizing the offensive and potentially dangerous septic tank effluents now being discharged onto the ground surface in most

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instances. Adequate funds, in the approximate magnitude of $250,000, are needed to provide acceptable treatment of all domestic wastes at Bureau of Indian Affairs installations.

TABLE H
WASTES TREATMENT NEEDS - MUNICIPAL*
April 1953

Needs	Number	Population Served by Facilities
New plant	2	6,845
Enlargement or Additions to Existing Plant	25	14,020
Replace existing plant	6	8,425
No project required	11**	5,165
Undetermined	1	600

* Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other pollution centers.

** Includes three plants needing tank maintenance and two plants which are under construction.

TABLE I
INDUSTRIAL* WASTES POLLUTION ABATEMENT NEEDS
April 1953

Needs	Number
New treatment plant or other pollution control measures	2
Enlargement or additions to existing plant	2
No project required	2
Undetermined	None

* Industries having separate outlets discharging wastes directly to watercourse.

TABLE J
STATUS OF MUNICIPAL* ACTION ON
POLLUTION ABATEMENT NEEDS
April 1953

Status of Action	Number of Municipalities*
Inactive	29
Active planning	3
Final plans approved	2
Under construction	2

* Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

TABLE K
STATUS OF INDUSTRIAL* ACTION ON
POLLUTION ABATEMENT NEEDS
April 1953

Status of Action	Number of Industries*
Inactive	4
Active Planning	
Final plans approved	
Under construction	
Undetermined	4

* Industries having separate outlets discharging wastes directly to watercourse.

TABLE L
MUNICIPALITIES AND INDUSTRIES NEEDING
IMPROVEMENTS FOR ABATEMENT OF POLLUTION
April 1953

Name and Location	Population Served	Improvement Needed
Cheechilgeetho, New Mexico*	45	Additional treatment and tank maintenance**
Cornfields, Arizona*	55	Additional treatment and tank maintenance
Crystal, New Mexico*	50	Tank maintenance
Flagstaff, Arizona	6,770	New plant
Fort Defiance, Arizona*	2,500	Additional treatment and tank maintenance
Fort Wingate School, New Mexico*	600	Tank maintenance
Gallup, New Mexico	7,500	Additional treatment**
Ganado, Arizona	400	Additional treatment and tank maintenance
Greasewood, Arizona*	70	Additional treatment and tank maintenance
Iyanbito, New Mexico*	30	Additional treatment and tank maintenance
Joseph City, Arizona		
Joseph City Dairy		Additional treatment
Westover Dairy		Additional treatment
Keams Canyon, Arizona*	325	Additional treatment and tank maintenance
Kin Li Chee, Arizona*	75	Additional treatment and tank maintenance
Klagetoh, Arizona*	100	Additional treatment and tank maintenance
Leupp,Arizona*	40	Additional treatment and tank maintenance
Moenkopi, Arizona*	125	Replace plant
Navajo Wingate Village, N. Mex.*	300	Tank maintenance
Oraibi, Arizona*	200	Replace plant
Petrified Forest National Monument, Arizona	100	Replace plant
Petrified Forest National Monument, Arizona	1,000	Replace plant
Pinedale, New Mexico*	125	Additional treatment and plant maintenance
Pinon, Arizona*	150	Additional treatment and tank maintenance
Polacca, Arizona*	100	Additional treatment and tank maintenance
Rehoboth Mission, New Mexico*	250	Additional treatment and tank maintenance

TABLE L (continued)

Name and Location	Population Served	Improvement Needed
Saint Johns, Arizona	600	Additional treatment
Sawmill, Arizona*	400	Additional treatment and tank maintenance
Seba-Daiki, Arizona*	55	Additional treatment and tank maintenance
Shungopavy, Arizona*	40	Additional treatment and tank maintenance
Snowflake, Arizona		
Snowflake Dairy		New plant
Springerville, Arizona	500	Replace plant
Steamboat, Arizona*	80	Additional treatment and tank maintenance
Tolani Lakes, Arizona*	65	Additional treatment and tank maintenance
Toreva, Arizona*	80	Additional treatment and tank maintenance
Tuba City, Arizona *	600	Additional treatment and tank maintenance
Wide Ruins, Arizona*	70	Additional treatment
Window Rock, Arizona*	350	Additional treatment and tank maintenance
Winslow, Arizona	6,500	Replace plant
Santa Fe Railroad		New plant
Indian Hospital*	75	New plant

* Installations on Indian-controlled lands.
** Final plans approved for remedial action.

At this time, the state water pollution control agencies are not in a financial position to conduct a factual study of water quality in relation to water uses and requirements. Additional funds and personnel are required to develop and administer a comprehensive program of pollution prevention and abatement that will assure clean waters throughout the basin. Present state technical personnel for survey and investigational work is so limited that the development of any comprehensive program appears out of the question at the present time. The provision of adequate personnel and funds to support an effective water pollution abatement program must, in the final analysis, depend upon an enlightened public. The state agencies are too short of funds to obtain even the background information required to implement a public educational program.

LITTLE COLORADO RIVER BASIN
LOCATION MAP

NO POLLUTION ABATEMENT NEEDS

POLLUTION ABATEMENT NEEDS UNDETERMINED

POLLUTION ABATEMENT NEEDED

POLLUTION ABATEMENT NEEDS INDICATED BY LETTERS APPEARING BESIDE 'POLLUTION ABATEMENT NEEDED' SYMBOLS, AS FOLLOWS

A NEW TREATMENT PLANT OR OTHER POLLUTION CONTROL MEASURES

B ENLARGEMENTS OR ADDITIONS TO EXISTING PLANT

NOTE - Numbers next to symbols or next to code letters represent number of pollution abatement needs in the category designated.

SCALE OF MILES 0 5 10 20 30

LITTLE COLORADO RIVER BASIN

INDUSTRIAL POLLUTION ABATEMENT NEEDS

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Public Health Service
DIVISION OF WATER POLLUTION CONTROL
MAP NO 5

GPO 986752

APPENDIX I
TABLE 1
BASIC DATA ON SOURCES OF MUNICIPAL POLLUTION
LITTLE COLORADO RIVER BASIN
April 1953

Name and Location	Approx. River Mile	Population Served by Sewers	Waste Treatment Provided	Adequacy of Treatment Facilities Cap'y	Adequacy of Treatment Facilities Opr.	Treatment Needs	Current Status of Municipal* Action
LITTLE COLORADO RIVER							
Nutrioso Creek (A) enters	285						
St. Johns	255	600	Secondary	Unsat.	Unsat.	Add'l. Treatment	Inactive
Cottonwood Wash #1(B)enters							
Silver Creek (C) enters	205						
Puerco River (D) enters	194						
Holbrook	191	2,350	Secondary	Sat.	Sat.	None	
Leroux Wash (E) enters	189						
Cottonwood Wash#2(F)enters	162						
Winslow	158	6,500	Primary	Unsat.	Unsat.	Replace Plant	Inactive
Winslow Indian Hospital 3/	158	75	None	--	--	New Plant	Inactive
Oraibi Wash (G) enters	120						
Leupp 2/	120	40	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
Canyon Diable (H) enters	119						
Cameron	42	30	Primary	Sat.	Sat.	None	
Moenkopi Wash (I) enters	41						
A. Nutrioso Creek: Springerville	NC-2	500	Primary	Unsat.	Unsat.	Replace Plant	Inactive
B. Cottonwood Wash #1: Petrified Forest National Monument 1/	CW-10	1,000	Secondary	Unsat.	Unsat.	Replace Plant	Inactive
C. Silver Creek: Overgaard		500	Secondary	Sat.	Sat.	None	

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TABLE I (continued)

Name and Location	Approx. River Mile	Population Served by Sewers	Waste Treatment Provided	Adequacy of Treatment Facilities Cap'y	Adequacy of Treatment Facilities Opr.	Treatment Needs	Current Status of Municipal* Action
D.Puerco River:							
Iyanbite, New Mex. 2/		30	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
Pinedale, New Mex. 2/	PR-125	40	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
Fort Wingate School 2/ New Mexico	PR-120	600	Secondary	Sat.	Unsat.	Tank Maintenance	
Wingate Ordnance Depot, New Mexico	PR-109	800	Secondary	Sat.	Sat.	None	
Navajo Wingate Village	PR-108	300	Secondary	Sat.	Unsat.	Tank Maintenance	
Rehoboth Mission, N.Mex.	PR-102	250	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
Gallup, New Mexico	PR-96	7,500	Intermed.	Unsat.	Sat.	Enlarge effluent pipe & Add'l Treatment	Final Plans Appr.
Gamerco	PR-96	250	Primary	Sat.	Sat.	None	
Cheechilgeetho 2/		45	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Final Plans Appr.
Black Creek enters							
E.Leroux Wash:							
Klagetoh 2/	LW-65	100	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
Wide Ruins 2/	LW-58	70	Primary	Unsat.	#Unsat.	Add'l Treatment	Inactive
F.Cottonwood Wash #2							
Steamboat 2/		80	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
Kin Li Chee 2/	CW-98	75	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
Ganado 2/	CW-91	400	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
Cornfields 2/	CW-80	55	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive

Greasewood 2/	CW-62	70	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
G.Oraibi Wash:							
Hotevila-Bacobi 2/	OW-54	120	Primary	Sat.	Sat.	None	
Oraibi 2/	OW-51	200	Primary	Unsat.	Unsat.	Replace Plant	Inactive
Tolani Lakes 2/	OW-25	65	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
1. Polacca Wash enters	OW-16						
2. Jeddito Wash enters	OW-9						
H.Canyon Diablo:							
1. San Francisco wash enters	CD-18						
I.Moenkopi Wash:							
Tuba City	MW-23	600	Primary	Unsat.	Unsat.	Tank Maintenance & *Add'l Maintenance	Active Planning 5/
Moenkopi	MW-22	125	Secondary	Unsat.	Unsat.	Replace Plant	
D-1 Black Creek:							
Crystal,N.Mex. 2/	BC-70	50	Secondary	Sat.	Unsat.	Tank Maintenance	
Sawmill	BC-50	400	Primary	Unsat.	Unsat.	Tank Maintenance & Add'l Treatment	Inactive
Ft. Defiance 3/	BC-39	2,500	Primary	Unsat.	Unsat.	Tank Maintenance & Add'l Treatment	Active Planning 5/
Window Rock 4/	BC-31	350	Secondary	Unsat.	Unsat.	Tank Maintenance & Add'l Treatment	Active Planning 5/
St. Michaels	BC-27	600	Primary	Undet.	Undet.	Undetermined	
Hunter's Point 2/	BC-23	120	Secondary	Undet.	Undet.	--	Under Construction
Pine Springs 2/		45	Secondary	Undet.	Undet.	--	Under Construction
Petrified Forest Nat'l. Monument 1/		100	Secondary	Unsat.	Unsat.	Replace Plant	Inactive
G-1 Polacca Wash:							
Pinon 2/	PW-83	150	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
Keams Canyon 4/	PW-58	325	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive

TABLE I (continued)

Name and Location	Approx. River Mile	Population Served by Sewers	Waste Treatment Provided	Adequacy of Treatment Facilities Cap'y	Opr.	*Treatment Needs	Current Status of Municipal* Action
Polacca	PW-46	100	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
Toreva	PW-42	80	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
Shungopavy 2/	PW-41	40	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
G-2 Jeddito Wash: Seba-Daiki 2/		55	Primary	Unsat.	#Unsat.	Tank Maintenance & Add'l Treatment	Inactive
H-1 San Francisco Wash: Flagstaff	SFW-30	6,770	None	--	--	New Plant	Inactive

- Primary treatment facilities adequate but primary treatment of wastes not deemed sufficient.
1/- One of two installations in the Petrified Forest National Monument.
2/- Indian School maintained by Office of Indian Affairs, Department of the Interior.
3/- Indian Hospital maintained by Office of Indian Affairs, Department of the Interior.
4/- District Headquarters, Office of Indian Affairs, Department of the Interior.
5/- Funds for remedial measures included in Fiscal Year 1954 budget estimates by Office of Indian Affairs.
* - Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.
Population equivalents (P.E.) of untreated waste or waste discharged to the watercourse have been omitted since analytical data were not available.
Main-stem river miles are computed from the confluence of the Little Colorado and Colorado Rivers.
Tributary river miles computed from the confluence of the principal tributary and the Little Colorado River.

TABIE 2
BASIC DATA ON SOURCES OF INDUSTRIAL* POLLUTION
LITTLE COLORADO BASIN
April 1953

Name and Location	Type Industry	Type Waste Produced	Treatment or Other Pollution Control Measures			P.E. Discharged	Pollution Abatement Needs	Current Status of Industrial* Action
			Degree	Adequacy Cap'y.	Adequacy Opr.			
LITTLE COLORADO RIVER								
Holbrook:								
Homestead Dairy	Food	Organic	Complete	Sat.	Sat.	5	None	
Joseph City:								
Joseph City Dairy	Food	Organic	Primary	Unsat.	Unsat.	7	Add'l Tmt.	Inactive
Westover Dairy	Food	Organic	Primary	Unsat.	Unsat.	7	Add'l Tmt.	Inactive
Winslow								
Santa Fe R.R. Shops (San.Sewage)	Misc.	Organic	None	--	--		New Plant	Inactive
SILVER CREEK:								
Snowflake:								
Snowflake Dairy	Food	Organic	None			7	New Plant	Inactive
PUERCO RIVER:								
Wingate Ordnance Depot, N. Mex.	Misc.	Organic	Secondary**	Sat.	Sat.		None	

* Industries having separate outlet and discharging wastes directly to watercourses.
** Final disposal by seepage and evaporation.

APPENDIX II
POLLUTION PREVENTION AND ABATEMENT MEASURES REQUIRED AT CERTAIN UNSEWERED COMMUNITIES OF ARIZONA

One very important pollution prevention and abatement need of the Little Colorado River Basin is the provision of a complete collection system and sewage treatment plant, or in some instances the extension of existing sewer lines with concurrent expansion of the sewage treatment plant, at certain communities in the Arizona part of the basin. Unsewered communities were not included in the text of this report.

The Arizona Department of Health recommends, in the interest of protecting public health, both a collection system and an adequate sewage treatment plant to serve the population indicated at the following communities:

Eager	900
Joseph City	350
Lakeside	900
Showlow	1,200
Snowflake	1,000
Taylor	500

The cost of providing sewerage and treatment facilities at the communities included in the above list is estimated at $290,000 by Arizona health authorities.

In addition, there are unsewered fringe areas about several communities of the Little Colorado River Basin which the Arizona State Department of Health also recommends be served by extensions of the existing community sewers. In all instances, additional sewage treatment facilities will be required to accommodate the increased plant loadings. The recommended population to be served by sewer extensions at each community is as follows:

Flagstaff	3,500
Hotevila-Bacobi*	300
Moenkopi*	250
Oraibi*	350
Sawmill*	750
Shungopavi*	100
Springerville	250
St. Johns	900
Toreva*	125

* Office of Indian Affairs installations.

The cost of providing the needed additional sewerage and enlarged waste treatment facilities at the communities listed above is estimated at $350,000 by health authorities.